

Eszteri Dániel

International legal expert at the Hungarian National Authority for Data Protection and Freedom of Information, formerly investigated cybercrime cases at the Budapest Police Headquarters Cybercrime Unit

István Zsolt Máté

*IT forensic expert
University of Pécs Faculty of Law*

REVIEW OF AN IN-DEPTH IT FORENSICS ANALYSIS OF A VIRTUAL WORLD CRIME

1. The initiation of the criminal investigation

In accordance with the effective regulations of the Hungarian Criminal Procedure Code, copyright crimes are investigated exclusively by the criminal directorates of the National Tax and Customs Office (hereinafter referred to as: NTCO). The following quote is from the denunciation and its amendment which was sent to one of the regional criminal directorates of the NTCO: «*a CGI (Computer Generated Imagery)¹ character named «avatar1» created by my own imagination was copied by an unknown perpetrator and was used to create pornographic pictures. These acts caused me moral and financial damage.*»

© Eszteri Dániel, István Zsolt Máté, 2016

© Національний університет «Острозька академія», 2016

¹Although the reporter used the phrase “Computer Generated Imagery” to define the created online (virtual) content, legal terminology usually specifies such creative contents created by users as ‘user generated content’.

-
- Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

Due to the denunciation and its amendment the investigating authority initiated the criminal investigation against person unknown suspected of having committed copyright infringement under article 385. § sections (1) and (3) of Act C. of 2012. of the Hungarian Criminal Code.

The denunciation and its amendment contained information that the actor (avatar1) is a three dimensional graphic object created in the online virtual world of Second Life. NTCO's official in charge came delegated an IT forensic expert for further clarification. Before the detailed presentation of the forensic examination, the general contractual background of the service and the nature of user created in-game content should be introduced.

2. The role of End User License Agreement in Second Life

The rights of the users of Second Life are laid down in the End User License Agreement (EULA) which must be accepted by every user before launching the virtual world simulation software. This is a general terms of service agreement which is defined unilaterally by the developer.

In the general terms and conditions the developer allows the user to use the software product and specifies the criteria and circumstances of the software use. The EULA should be accepted by the user during the installation or the first run of the software. The software can only be used if the terms of the EULA were accepted. These contracts usually cover the terms of end user rights and obligations in great detail.

One of the most well-known features of Second Life is the fact that it is not Linden Lab but the inhabitants themselves who build the in-game virtual environment. Inhabitants who created virtual items and tools can freely dispose of them. User generated content can be an instrument of purchase for example.

▪ Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

Linden Lab as the developer and operator of Second Life grants the users an in-game 'copyright' on the objects created, modified or uploaded by them.²

3. Introduction to object permissions in Second Life

Object permissions are technical guarantees for exercising exclusive copyright on user generated content in the virtual world of Second Life. They ensure that all transactions made in the virtual economy with objects were previously accepted by their author within the software.

The following relevant permissions allow the control over user created objects:

- *Modify*: The next owner can modify the object. Turning it off results in the denial of every modification.

- *Copy*: The object's next owner can transfer it to another user. If the object is transferred from the inventory to the virtual in-game world, a copy of the object stays in the inventory. By turning this option off, copying becomes prohibited; in this case, if the user moves the object from the inventory to the virtual in-game world, the object gets out of the inventory until the user puts it back there.

- *Transfer*: By turning this option on, the object's next owner can hand it over to other users. If the object makes the copying possible (copy option is turned on), then a copy of the object can be transferred, and the original stays with the original user. If the object does not allow copying (copy option is turned off), then only the original copy can be handed over. If the object allows copying but no transferring, then any number of copies can be made by the user for his or her own use, but none of them can be transferred.

² Second Life Terms of Service

▪ Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

4. The assessment of the financial value of an avatar in the virtual economy

Avatar objects identified in the denunciation and created by the victim are acknowledged by the software developer as the user's in-game intellectual property. Intellectual property and virtual items created in the virtual world are treated as marketable objects according to the EULA and the software's technical background. The right of disposal regarding virtual objects can be derived from the EULA and should be considered as in-game intangible asset.

This statement is also confirmed by the fact that Second Life has its own working economy and currency called Linden Dollar (abbreviated as: L\$). Inhabitants can create new virtual items, which they may sell later. Moreover, they can offer and use virtual services. Virtual currency can always be converted to real USA dollars. Although the currency's exchange rate is affected by fluctuations, it usually represents a value between 230-260 L\$/USD.³ Goods created in virtual worlds can represent a real world value and as such, their illegal removal or duplication can cause financial loss on the original author's side.

5. The ground for virtual copyright infringement and calculating the financial loss

According to the available information in the case, the victim created several objects (avatars) representing humans in the three-dimensional world of Second Life. The unknown perpetrator made illegal copies of these objects by using a special software as a tool, then used these replicas for creating pornographic images and video materials and published them on a popular picture and video sharing website.

³ For example see the virtual currency exchange of Virwox.com: <<https://www.virwox.com/>> accessed 16 October 2016

▪ Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

As, in accordance with the End User License Agreement of Second Life, the compiled code of user created objects becomes the in-game intellectual property of the user, copying, using and 'counterfeiting' the objects without consent violates the copyrights of the original author. The subject of the infringement here is not the object but the part of the code which is responsible for its appearance. The infringement is committed for the compiled code responsible for the appearance.

Article 385 of the Hungarian Criminal Code (Act C. of 2012.) describes the statutory definition of infringement of copyright as crime. The crime is committed if a person infringes the copyright or certain rights related to copyright of another person afforded under the Copyright Act and/or thereby causing financial injury.⁴ The extent of the penalty is in line with the financial injury caused by the crime. So the more financial injury the criminal act causes, the more serious sanction should the perpetrator count on.

The behavior is criminalized if the perpetrator infringes the intellectual property rights of one of the authors or related right holders listed in the Hungarian Act on Copyright. This crime is committed when financial injury occurs on the side of the victim and it is caused by the act of the perpetrator (by the infringement of copyrights).

We should not consider the amount of loss of financial injury in the retail price of the client software installed by the users, if we want to calculate it in connection with the illegal copying of the user generated content, because the infringement was not done to the whole software but only to its smaller part: the compiled code of the virtual object. It is a very difficult task to estimate the price of a certain user-created virtual object. We should keep in mind that almost every item in Second Life has a price in real life due to the internal currency of the virtual world and its convertibility to real money. If we want to calculate the

⁴ Hungarian Criminal Code article 385. § sections (1)-(2)

▪ Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

amount of the loss of financial gain, then we should take into account the market relations, the average prices, and the unique attributes of the virtual item. In such case, this seems a very difficult task, because the expert should have good knowledge of the working mechanisms of the unique closed economy and market, as well as of the crime related object's properties, parameters and design.

6. IT examination of the criminal act

a. Identification system of avatars

In order to reconstruct the act of the perpetrator, the forensic expert examined the unique identification system of creatable objects in Second Life. It was determined that the objects created in Second Life - either representing persons, animals or objects - have a unique identifier called 'Universally Unique Identifier' (UUID). The UUID is a 128 bit long number which is created so that the collision (two different objects with the same UUID) is very unlikely due to the high number of variations.⁵ The format of UUID is the following:

key uuid = "xxxxxxxx-xxxx-4xxx-yxxx-xxxxxxxxxxxx";

Where character '4' means 4, character 'x' means hexadecimal numbers in a range of '0,1,2,3,4,5,6,7,8,9,a,b,c,d,e,f' and character 'y' means a value of '8-9a-b'.

The basic appearance of avatars is defined by nine body part objects. The 79 parameters of body part objects can adopt a rate between 0 and 100 in the graphical designing tool.⁶ In order to identify the particular avatars, the forensic expert asked the victim to give him the physique parameters of the avatars concerned. The expert came to the conclusion that similarity between certain

⁵ <<http://wiki.secondlife.com/wiki/UUID>> accessed 22 May 2016

⁶ <http://wiki.secondlife.com/wiki/Appearance#Shape_Tab> accessed 22 May 2016

▪ Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

avatars can be identified by comparing the avatars' shape parameter groups to each other. This method rules out the subjective elements of a simple visual comparison. The parameters of the object can be examined when logged in to the user account by choosing the object in question and viewing the specific properties.

An illegal mode of query an object's parameters is the use of the software called Copy Bot. The software connects to Second Life and enables the user to copy objects without the permission of the original author.

The objects exposed to this activity via Copy Bot software are the objects which can be 'seen' by the user, meaning that the targeted object needs to be right next to the avatar of the copier. Copy Bot user should be logged in to the system as an avatar and is able to copy other avatars, objects or textures nearby.

In addition to the end user license agreement of Second Life, the general doctrines of copyright law also prohibit the unauthorized copying of original user generated content. According to the Hungarian Act on Copyright it is the author's exclusive right to make copies of the protected work or to allow someone else to make copies.⁷ Pursuant to the act, digital storing of the protected work on electronic device is considered copying. The author can allow other users to copy if the created work is set as «copy free» virtual item. The technical settings and the EULA of Second Life allow the user to previously grant the right to copy for other users. The use of Copy Bot does not comply with the agreement and should be considered as unauthorized copying by bypassing the technical features of Second Life.

b. Obtaining digital evidence from simulated virtual environments

⁷ Article 18 of Act LXXVII. of 1999. on copyright law

▪ Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

In the next part of the expert inspection, with regard to the IT and legal facts hereby presented, the possibilities on how to obtain digital evidences from the virtual environment were examined.

The provided service can be defined as a simulation software where users are able to create personal contents. The simulation runs constantly on the relevant servers. This definition is adequate to the content of 'Software as Service' (SaaS) definition for cloud services, where the virtual space (Second Life) itself is the provided service.

In the case of cloud services, the computing performance and other resources (memory, storage space etc.) are usually provided by a group of servers which are connected by high speed transferring media (optical cables).

In the environment of the cloud services, the access to particular system levels is strongly limited. For example, the main characteristic of the SaaS environment is that the user can only access the top level – the software - of the system.

In the examined case, the hardware and network level of Second Life (data centers and communications between them), the operation systems running on particular servers, the hypervisor programs responsible for shaping the virtual world, the applications creating the actual simulation and the data controlled by them are not accessible to users. Via the Second Life application, users access a graphic interface generated by the program. All of their activities take place through this interface on each server.

Due to the design of SaaS system, only the provider (in this case Linden Lab) can access functional data without restrictions. Digital evidence related to the infringement in the virtual world can only be acquired with the cooperation of the service provider.

The topic of obtaining digital evidence from cloud based services was researched by Dykstra and Sherman, who tried to retrieve digital data from a

-
- Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

cloud service.⁸ The conclusion of the case study was that the expert could obtain digital evidence on condition that all levels of the system were accessible. There is no practical example of an external expert obtaining full access. The only practical solution mentioned by the study is to order a data export from the service provider containing all the data relevant to the case.

Further research on obtaining digital evidence from cloud computing services shows us that, without the cooperation of the service provider, the acquirement of the relevant data cannot be achieved. Good examples are examinations based on 'Proof of Past Data Possession' (PPDP⁹) or 'Provenance Aware Storage System' (PASS¹⁰).

To summarize the above: based on the available data and the specifics of the examined IT system, the forensic expert concluded in the end of the research that proving or confuting the victim's statements can only be possible with the cooperation of the service provider of the virtual world platform.

c. Parameters necessary to identify avatars and their interpretation

In the following section of the research, the expert specified the data set of digital evidence to be obtained which was necessary for the further examination by requesting the cooperation of the service provider. These are the following:

- i.** The saved object designs with their UIIs provided by the victim.
- ii.** Obtaining the data of creation in relation to the objects with UIIs provided by the victim.
- iii.** Performing searches in the inventories of all users for object parameters with UIIs provided by the victim.

⁸ Dykstra – Sherman: 'Acquiring forensic evidence from infrastructure-as-a-service cloud computing: Exploring and evaluating tools, trust, and techniques' (2012) *Digital Investigation* 9, S90–S98. p. 93.

⁹ Zawoad, S. – Hasan, R.: 'Towards building proofs of past data possession in cloud forensics' (2012) *SCIENCE* volume 1.4. p. 202.

¹⁰ Muniswamy-Reddy – Macko – Seltzer: 'Provenance for the Cloud.' (2010) *FAST*. Vol. 10. p. 2.

▪ Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

iv. In case of identical objects, the date of their creation should be compared and listed in chronological order.

The critical point of the service provider's examination is the assessment of the identical nature of two objects and its margin of error: how many parameters of the objects can differ to be able to consider them as identical or to confirm their 'parent-child relationship'? Assuming that the total number of possible variations is based on 79 parameters each with a value of 100, the result is 100^{79} variations in total.

It is possible to assess the level of reasonableness of the expert's argumentation based on the number of identical parameters:

Merits	Conclusion about identity	No. of avatar parameters found identical
100%	categorical	79
99-51%	probable	between 41-78
below 50%	possible	below 41

Considering that avatar parameters describe visual specifics, the identity and margin of error concerning the parameters should also be defined. The margin of error in this context marks the scale of derogations (plus/minus) within which the examined parameters can be considered as identical. With regard to the circumstance that no developed methodology exists for this type of case, and no information on the margin of error is yet available, the expert suggested a value of plus/minus 3 (equal to 6% of each parameter's value range), taking into consideration the visual difference in the appearance of avatars induced by parameters.

▪ Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

To summarize: The parameters of the victim's avatars are considered identical to the parameters of the avatars copied by the perpetrator if the values of the parameters show a derogation of ± 3 points at most. The abovementioned methodology of digital evidence evaluation can be clarified by the data provided by the service provider.

d. Methods to identify the perpetrator

If the service provider performs the search mentioned in the previous chapter and an identity is found, the virtual object that can be connected to the committed act can be defined. The virtual identity and the natural person behind can be connected by examining the registry of logins to the used Second Life profile. If the profile or the logins show IP addresses connected to Hungarian internet service providers, than the personal data of the subscriber can be requested by the investigation authority.

At this point, it has to be noted that, from a criminal procedure law perspective, reaching the server operator of Second Life can be difficult because it is not seated in the same country. If the Hungary-based investigation authority wishes to receive information about the user of the affected Second Life account, it can only be achieved through international legal assistance procedure.

7. Results and findings of the examination

In accordance with the data supplied during the IT forensic expert examination and the information available on the virtual world of Second Life, the following two main answers were given to the request of the investigation authority:

1) The expert shall record the information technology based (the code) and visual (the design) characteristics of the concerned three dimensional shapes and

▪ Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

components called «avatar1», «avatar2», «avatar3», «avatar4», «avatar5», «avatar6» and «avatar7»:

The originality of avatar objects created in virtual world is provided by parameters of the object's 'web design'. In order to determine the identity of two or more objects, the description of these parameters is sufficient. The fixing of the visual content in the form of 2D screen shots of 3D objects is not suitable for identification due to the subjective nature of assessing similarity. In order to identify certain objects the description of the UUID is also necessary.

2) The expert shall support the identification of the possible suspect(s) or other relevant persons in accordance with the denunciation's information by connecting the information with the data and by acquiring more possible data:

The identity of the person described in the victim's denunciation could not be determined based on the legally obtainable data, with regard to the circumstance that relevant digital evidence can only be accessed in cooperation with the service provider.

8. Final conclusion

Although virtual worlds for most people simply do not exist (because of low level of digital literacy, lack of interest or knowledge) we cannot simply ignore the phenomena of virtual events, acts and their examination. The classic legal terminology should fit the parameters of the new digital environment, and virtual activities such as investigation or mediation also have to be reinterpreted. It is also important to work out and publish the examination methods for crimes committed in virtual environments for law enforcement and judicial officials in order to prevent incorrect or false interpretation of the law and wrong decisions in absence of appropriate knowledge.

9. Literature:

- a. Dykstra – Sherman, ‘Acquiring forensic evidence from infrastructure-as-a-service cloud computing: Exploring and evaluating tools, trust, and techniques’ (2012) *Digital Investigation* 9, S90–S98.
- b. Kiss, Zoltán, ‘A vagyoni hátrány megállapítása szerzői és szomszédos jogok megsértése miatt indított eljárásokban (Determining the amount of pecuniary loss in procedures for infringement of copyright)’ (2001) *Iparjogvédelmi és Szerzői Jogi Szemle (Industrial Property Law and Copyright Law Review)*, year 106. no. 3.
- c. Muniswamy-Reddy – Macko – Seltzer, ‘Provenance for the Cloud.’ (2010) *FAST*. Vol. 10.
- d. Zawoad, Shams, and Hasan, Ragib, ‘Cloud Forensics: A Meta-Study of Challenges, Approaches, and Open Problems.’ (2013) arXiv preprint arXiv:1302.6312
- e. Zawoad, Shams, and Hasan, Ragib, ‘Towards building proofs of past data possession in cloud forensics’ (2012) *SCIENCE* volume 1.4

Dániel Eszteri, István Zsolt Máté

Review of an In-Depth IT Forensics Analysis of a Virtual World Crime

In Hungary, there is an active practice for inspecting crimes committed in information technology environments as well as crimes affecting intellectual property (the two areas often overlap). Moreover, the moment has recently come when a criminal infringement of copyright occurred in a very special environment: in the virtual world of Second Life. We discuss the question in detail that how digital evidences can be obtained from simulated virtual environments from a legal and IT forensic perspective based on a concrete criminal case where illegal copies of avatars appeared in Second Life.

-
- Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.

In virtual world simulations hundreds of thousands of users are able to contact each other directly and shape the surrounding programmed environment. Users can interact with each other and the simulated environment by controlling their character - a personalized avatar - and shape the virtual world collectively. Such worlds continue to evolve even if a user quits the game as its servers run 24 hours a day to serve online users. It goes on even if somebody is not active in it for a certain amount of time.

The crime analyzed in this paper, namely copyright infringement was committed in the virtual world of Second Life against the owner of an avatar by illegally copying the user generated content created by the owner. In the following points, we present the exact practice employed in the committing this crime in this specific and extraordinary environment.

-
- Review of an In-Depth IT Forensics Analysis of a Virtual World Crime / Dániel Eszteri, István Zsolt Máté // Часопис Національного університету «Острозька академія». Серія «Право». – 2016. – № 2(14) : [Електронний ресурс]. – Режим доступу : <http://lj.oa.edu.ua/articles/2016/n2/16mizvwc.pdf>.